Advances in Agriculture, Sciences and Engineering Research
http://www.ejournal.sedinst.com
© Science Education Development Institute, 2014 **Volume 4 (7) Jul: 1677 - 1686, 2014**
Printed in Nigeria **ISSN: 2276 – 6723**

EVALUATION OF SOME ENGINEERING PROPERTIES OF WATERMELON SEED RELEVANT TO THE DESIGN OF PROCESSING EQUIPMENT

Adekanye, Timothy Adesoye
Department of Agricultural and Biosystems Engineering, Landmark University, P.M.B.1001, Omu - Aran, Kwara State, Nigeria. Email: adekanye.timothy@lmu.edu.ng.

ABSTRACT

Some physical and mechanical properties of watermelon seeds were investigated in this study. Size, surface area and seeds were characterized using established procedure. The volume, mass and density of the seeds were determined using water displacement method. The static coefficient of friction of water melon seeds were determined with reference to three different structural surfaces; plywood, glass and galvanized metal sheet. The compression test was carried out to determine the load, energy and deformation at peak and yield of major and intermediate axis of watermelon seed. The result of the experiment on size shows that watermelon seed has a wide range of size distribution. The surface area and the shape also depend on varieties. The angle of repose ranges from 18^0 to 26^0 at storage moisture content. The static coefficient of friction depends on the type of structural surface involved. The sphericity of the black, brown and white – black varieties was 0.483, 0.535 and 0.489 while the roundness of black, brown and white – black varieties was 0.776, 0.639 and 0.856. The density of watermelon seed was lower than the density of water. The densities of black, brown and white – black varieties were 0.932, 0.935 and 0.928 at storage moisture level.

KEYWORDS: Watermelon seed, physical properties, moisture content, angle of repose, Surface area

Received for Publication: 19/05/14 Accepted for Publication: 25/07/14

INTRODUCTION

Watermelon is large (Cucumis melon), oval, round or oblong in shape. The skin is smooth, with dark green rind or sometimes pale green stripes that turn yellowish green when ripe. Watermelon is an aggressive annual crop that prefers environmental temperature greater than 21^{O}C. Watermelon is a drought tolerant crop which belongs to the Cucurbitaceae family of flowering plants. It is generally considered to be of the Citrullus species and has been referred to as Citrullus Vulgaris. It also serves as a good source of phytochemical and lycopene, a red carotenoid pigment which acts as antioxidant during normal metabolism and protects against cancer (Perkins and Collins, 2004). It is cultivated in a wide range of tropical, semi tropical and rigid regions of the world. It is originally found in Southern Africa, the indigenous people, in their search for water-containing foods, selected varieties with low glycoside content. In ancient times, the watermelon was cultivated in Egypt, from where followed the spread to the Mediterranean areas and in an eastern direction to India [27]. It is grown for its large fruit that weighs from five to forty pounds depending on the variety. Watermelon contains about 90% water, which serves as sources of water for some people in the desert. Other importance includes staple food, animal feed and fermentation for alcohol production [3].

Watermelon is a very rich source of vitamins, can be served for breakfast, as an appetizer or snack, depending on how it is prepared [14]. It also serves as a good source of phytochemical and lycopene, are d carotenoid pigment which acts as antioxidant during normal metabolism and protects against cancer [26]. Watermelon fruit contains large quantities of seeds. The seeds can be cooked and dried and served as snacks. The seeds might also be cooked, ground (West Africa) and fermented for use as a flavour enhancer in gravies and soups [21].

Processing of agricultural products involves harvesting, separation, cleaning, handling and storing. Information on physical and mechanical properties of agricultural products is very important for the design of processing and handling equipment. These properties must be determined at laboratory conditions [28; 13; 9]. Several researchers have carried out studies on the physical and mechanical properties of some agricultural products [2; 22; 16; 18; 7). Makanjuola [19] determined the size and shape of the seeds of two melon varieties and correlated the dimensions of the seeds and kernels. Paksoy and Aydin [25] evaluated some physical properties; length, width, thickness, geometric mean diameter, sphericity, mass, volume, bulk density, true density, porosity and static coefficient of friction of squash seeds at 6.4%(d.b) moisture content. Joshi *et al*., [11] studied the average length, width, thickness, unit mass, bulk density, true density, porosity, the static coefficient of friction and angle of repose of pumpkin seeds and kernels at 4% (d.b).

Physical properties of watermelon seeds are essential for the design of equipment for handling, processing and storing; and are the most important factors in determining the optimum vacuum pressure of the precision vacuum seeder [12]. The physical properties of watermelon seeds vary with the cultivars. Better understanding of the physical properties are also essential in order to optimize various factors of watermelon seeds (e.g. threshing efficiency, pneumatic conveying and storage) [17]. In order to increase watermelon seed production quantity and quality, agricultural engineering researchers have realized the need to develop, use, and improve modern watermelon machinery technology [5; 6]. The objective of this research is therefore to evaluate some physical and mechanical properties of watermelon seeds at safe moisture content useful for the design of equipment for handling, processing and storing. The properties examined were size, sphericity, static coefficient of friction against different materials, roundness, angle of repose, mass, density and volume.

MATERIALS AND METHODS

Sample preparation

Watermelon seeds used in this experiment were obtained from a seed store in Ilorin, Kwara State, Nigeria. Three varieties were chosen for this study. The three varieties were local varieties identified by colour. The varieties chosen were black, brown and white – black (Figure 1). The seeds were carefully cleaned to remove dust, foreign materials and broken or immature seeds. A total number of 200 seeds were selected from each variety as samples; these samples were thoroughly mixed together before carrying out investigations on engineering properties.

Figure 1: Black, brown and white-black watermelon seeds

Moisture content determination

Samples were taken from each variety and grinded to form finer particles. The grinded samples were weighed separately and kept in the oven for a period of two hours at a temperature of 130^{o}C and reweighed after oven drying as described by Ajibola *et al*., [1]. Weight loss is the weight of moisture in the seeds and this was used in computation of the moisture content of the seeds at storage.

Size, surface area and sphericity

A sample of 200 seeds was randomly selected for measurement of major, minor and intermediate diameters using micrometer screw gauge. A vernier calliper with 0.001mm accuracy was used for the measurement of the length, width and thickness in three directions. The geometric mean diameter was determined using the method suggested by Song and Litchfield [17], by using Equation 1. The sphericity of watermelon seeds was obtained using the formula given by Mohsenin [20], Jean and Ball [10] and Gursory and Guzel [9].

$$\text{size} = (abc)^{1/3} \qquad (1)$$

Where:
a = length of seed
b = width of seed
c = thickness of seed

Volume, mass and density

200 samples were selected randomly from each variety. Each of the seeds were weighed on the digital sensitive weighing balance (Model TM 2000) to find the mass when immersed in water to determine the volume of water displace which is the volume of the seed using a measuring cylinder. The density was evaluated using expression below

$$\text{Density} = \text{mass} / \text{volume} \qquad (2)$$

Static Coefficient of Friction

The static coefficient of friction for watermelon seed was determined on three materials, plywood, glass and mild steel respectively using the method described by Alonge and Adegbulugbe [2]. A box of 150mm × 150mm × 40mm with the top and the bottom opened was filled with the seeds and placed on adjustable tilting table onto which the material to be tested has previously been fastened. The box was placed in one end of the surface and raised slightly so it was not touching the material. A screw device slowly tilted the table until the friction force between the seeds and the material was overcome by gravity and movement down the slope began. The angle of inclination was read from a graduated protractor attached to the tilting table. The tangent of the angle of inclination is the static coefficient of friction of the seed in the material. For each replication, the sample in the container was emptied and refilled with a new sample [4; 8; 11; 23; 24].

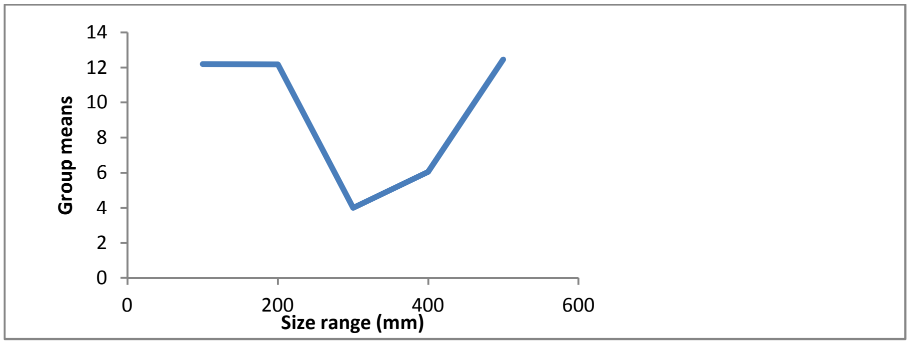
RESULTS AND DISCUSSION

The data recorded in each test condition were analyzed statistically**.** Duncan multiple range tests were used to compare the means. From the results of the analysis, the effects of moisture content, loading position and variety on load, deformation and energy of watermelon seeds were evaluated.

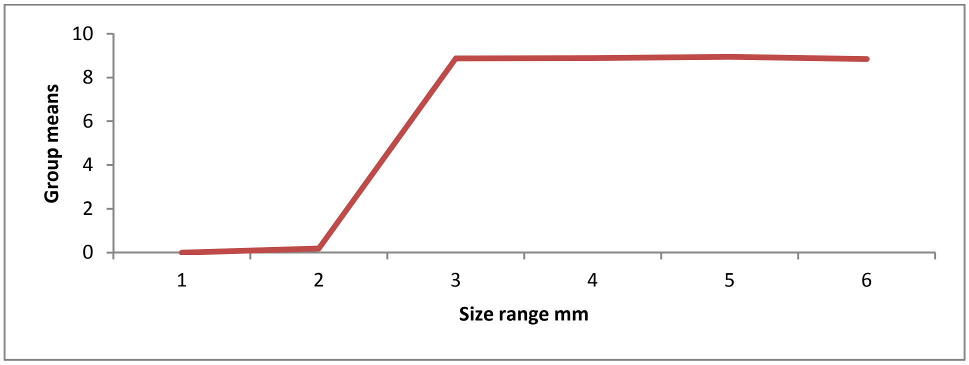
Size

The result obtained from evaluation of size of three varieties of watermelon seed are presented in Figure 1 shows the range of size distribution of watermelon seed in the major axis. Black watermelon seed has a wider size distribution of range of 5.49 – 9.91mm while – black seeds have a size distribution range of 10.07 – 13.49mm. Figure 2 shows the range of size distribution of watermelon seeds in the intermediate axis. Black seeds have a wider range distribution of 4.35 – 8.66; brown seeds have a size distribution of 2.63 – 6.68mm.

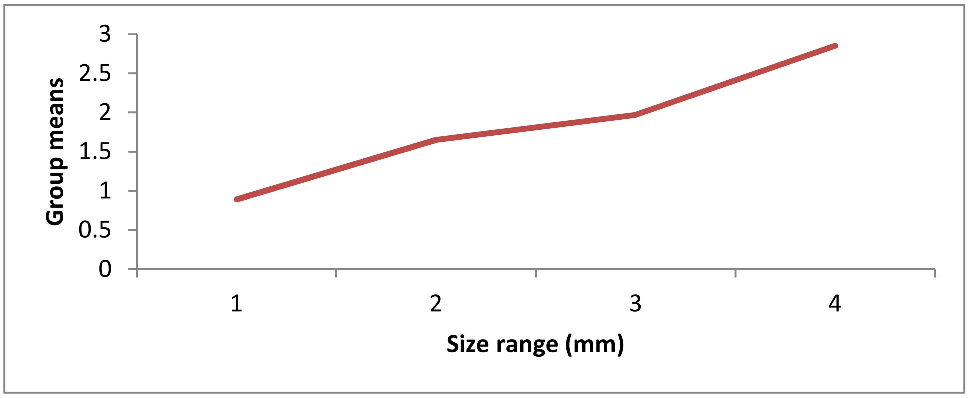
Figure 3 shows the range of size distribution of watermelon seeds in the minor axis, black has a wider range of size distribution of 1.52 – 2.96mm and brown has a size distribution of 1.57 – 2.68mm while black has a size distribution range of 1.75 – 2.93mm. Hence, the size distribution range characteristic is same for major and intermediate axes in all the three varieties but different in the minor diameter. These parameters are useful in design of screening equipment for watermelon seed.



a: major diameter for black variety

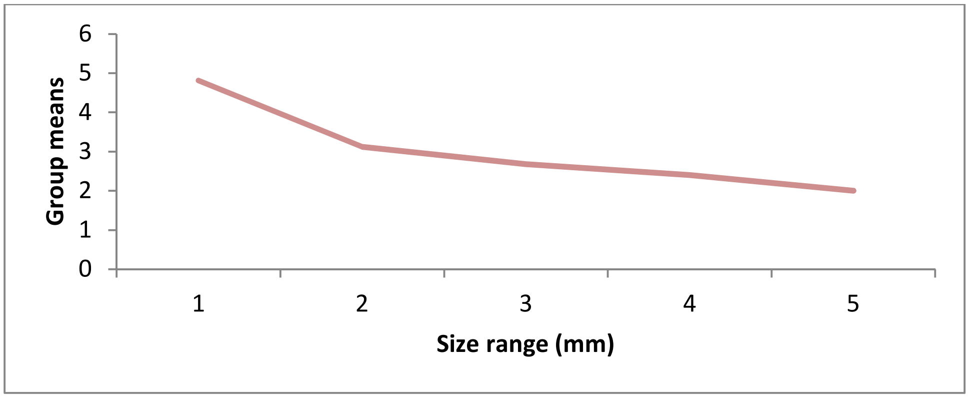


b: Major diameter for brown variety

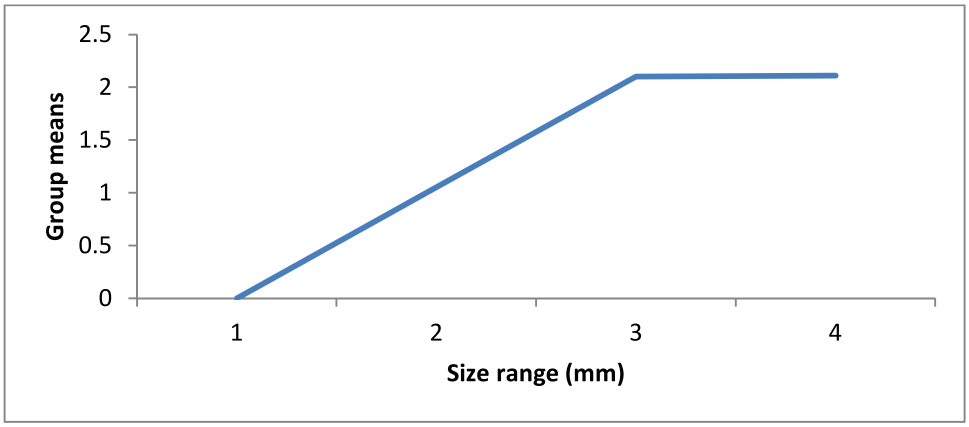


c: Major diameter for White – black variety

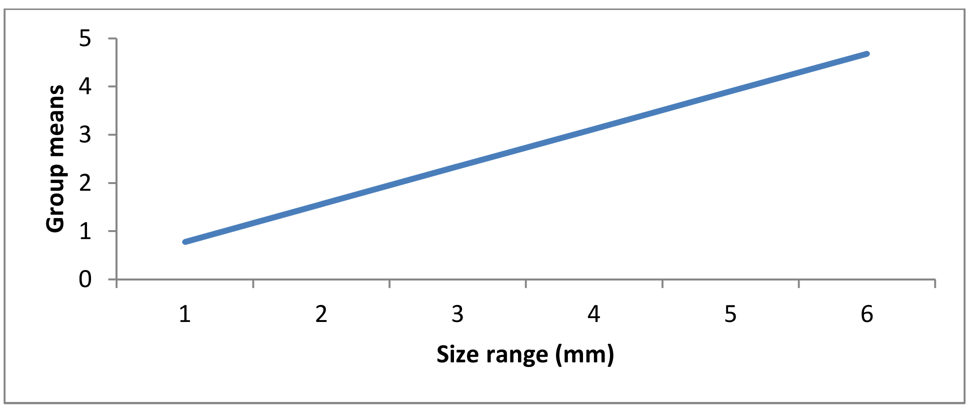
Figure 1: Size distribution of major diameter of watermelon seeds



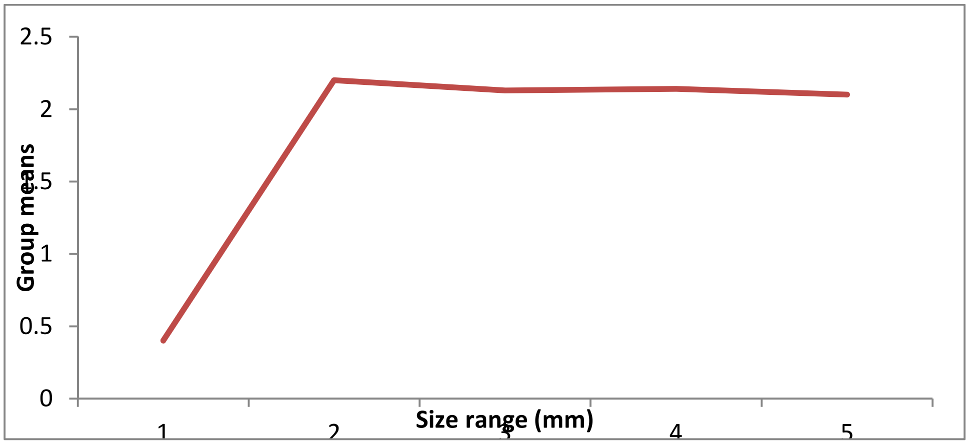
a: Intermediate diameter for Black variety



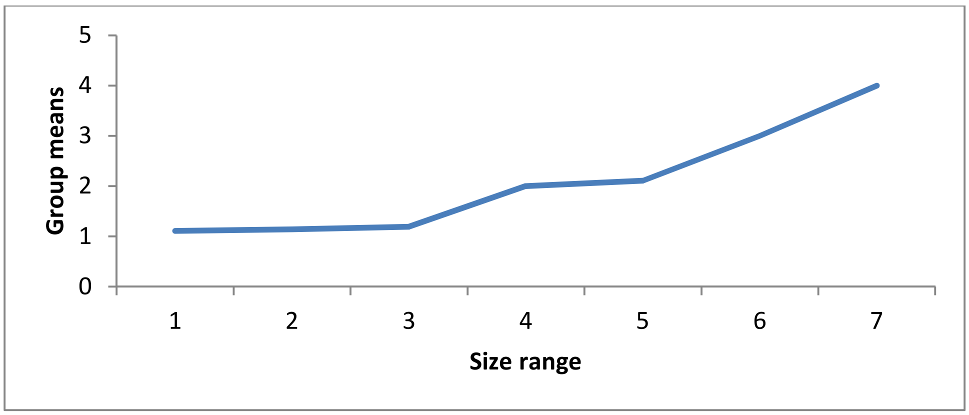
b: Intermediate diameter for White – black variety



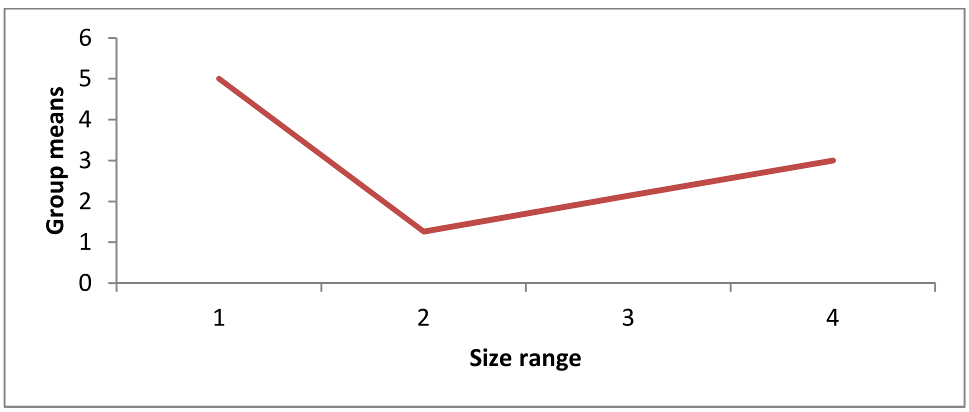
c: Intermediate diameter for brown variety
Figure 2: Size distribution of intermediate diameter of watermelon seeds



a: minor diameter for Brown variety



b: minor diameter for Black variety



c: minor diameter for White – black variety

Figure 3: Size distribution of minor diameter of watermelon seeds

Shape (Roundness and Sphericity) and Surface Area of Watermelon seed

The result obtained from the investigation of sphericity of the varieties of watermelon seed are presented in Table 1. The least sphericity was 0.483 while the highest value was 0.535. Results of evaluation of sphericity revealed that the brown variety is most round followed by black and white varieties. The black has a larger surface area followed by white-black and brown variety. Figure 4 shows the frequency distribution of surface area of different varieties of watermelon seed on the graph. This parameter is useful in the design of packaging structures of watermelon.

Density and Coefficient of friction of watermelon seed

The results of evaluation of density of 3 varieties of watermelon seed are shown in Table 2.The average density of black, brown and white-black are 0.933, 0.935 and 0.934 g/cm^3 respectively. The results show that density of three varieties of watermelon seed is lower than that of water, hence water can be used to separate watermelon seeds from other materials by principle of floatation. Density determination could be used for design of separation equipment for watermelon seed. Static coefficients of friction for three varieties were determined for three structural surfaces. The steepness of the upper depends on the types of material used. Table 3 shows that steepness is faster in glass followed by metal and wood.

Angle of repose of watermelon seed

The angle of repose of the seeds is presented in Table 4. The results show that at moisture content of 9.28% (w.b) for black variety, the angle of repose was 25^{o}C, at moisture content of 9.34% (w.b) of brown variety the angle of repose was 18^{0}C while at moisture content of 9.45% (w.b) of white – black variety, the angle of repose was 26^{0}C.

Moisture content of watermelon seed at storage

Table 5 shows moisture contents of three varieties of watermelon seed at storage. Black has the highest moisture content followed by brown and black. The moisture content of white – black was 9.45% (wet basis), brown was 9.34% (wet basis) and black was 9.28% (wet basis). Hence, watermelon could be stored under this moisture content safely without problem of deterioration due to high moisture level.

Table 1: Sphericity of watermelon seed

Variety	Mean	Standard deviation	Variance
Black	0.48	0.02	0.000
Brown	0.54	0.03	0.001
White – black	0.49	0.02	0.001

Table 2: Density of watermelon seed (g/cm^3)

Variety	Mean	Standard deviation	Variance
Black	0.93	0.002	0.000
Brown	0.94	0.004	0.000
White – black	0.93	0.003	0.000

Table 3: Coefficient of friction of watermelon seed

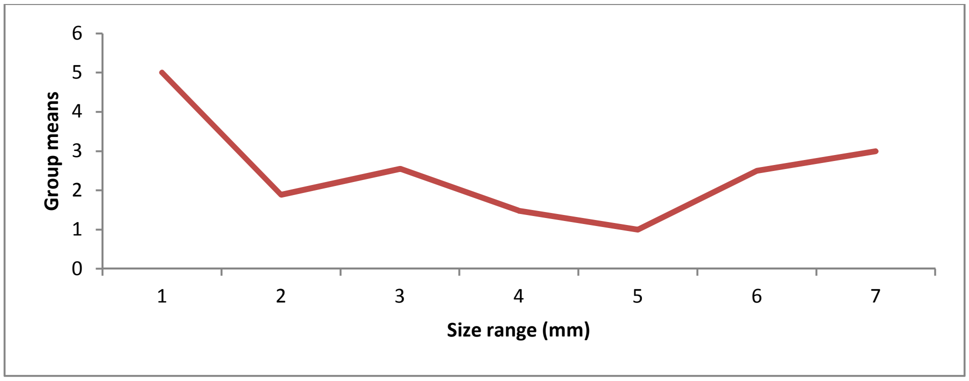
Variety	Metal	Glass	Plane Wood
Black	0.40	0.38	0.63
Brown	0.34	0.47	0.58
White – black	0.36	0.40	0.60

Table 4: Angle of repose

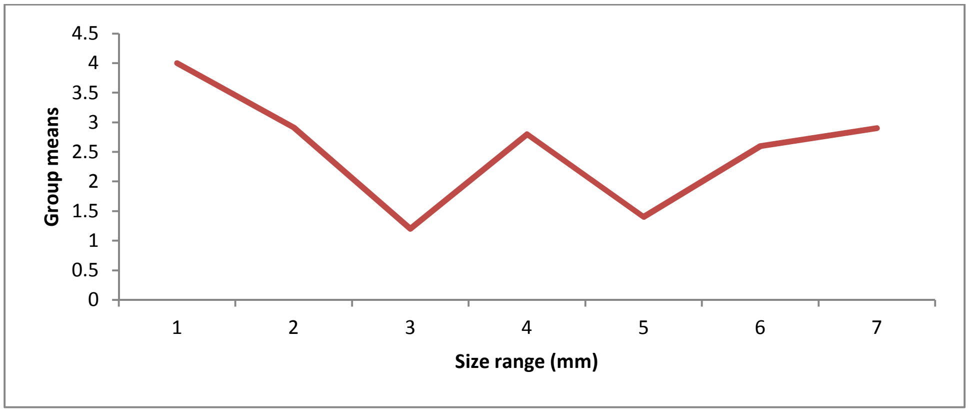
	Variety I Black	Variety II Brown	Variety III White – black
Angle of repose	25^0	18^0	26^0

Table 5: Moisture content of watermelon seed at storage

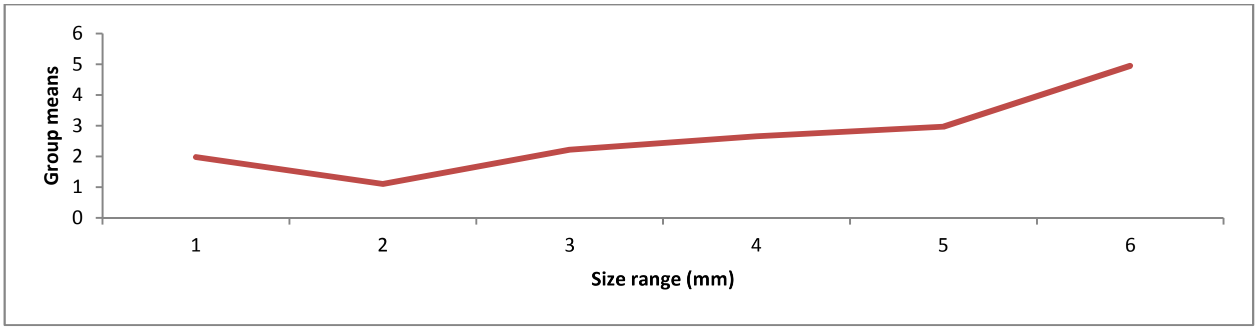
	Variety I Black	Variety II Brown	Variety III White – black
Moisture content	9.28% (wet basis)	9.34% (wet basis)	9.45%(wet basis)



a: area of Black variety



b: area of Brown variety



c: area of White - black variety

Figure 4: Frequency distribution of surface area for three varieties of watermelon seeds

CONCLUSIONS

Some physical and mechanical properties of watermelon seed were determined. The result of the experiment on size shows that watermelon seed has a wide range of size distribution. The surface area and the shape also depend on varieties. The angle of repose ranges from 18^0 to 26^0 at storage moisture content. The static coefficient of friction depends on the type of structural surface involved. The sphericity of the black, brown and white – black varieties was 0.483, 0.535 and 0.489 while the roundness of black, brown and white – black varieties was 0.776, 0.639 and 0.856. The density of watermelon seed was lower than the density of water. The densities of black, brown and white – black varieties were 0.932, 0.935 and 0.928 at storage moisture level.

REFERENCES

1]. Ajibola, O.O., Eniyemon, S.E., Fasina, O.O and Adeeko, K.A. 1990. Mechanical Expression of Oil from Melon seeds. *Journal of Agricultural Engineering Research*. 45(1). 45-53.

2]. Alonge, A.F. and Adegbulugbe, T.A. 2005. Some physical properties of groundnuts. *Journal of Agricultural Engineering Technology (AET)*, volume 13.

3]. Athens, G. 1998. Commercial Watermelon Production. Cooperative Extension Service. The University of Georgia.

4]. Aviara, N.A., Gwandzang, M.I. and Haaque, M.A. 1999. Physical properties of guna seeds. *Journal of Agricultural Engineering Research*. 73: 105-111.

5]. Aviara, N.A., Ibrahim, E.B. and Onuaha, L.N. 2014. Physical properties of *Brachystegia eurystegia* seeds as affected by moisture content. *Int J. Agric & Biol Eng*., 7 (1): 84-93.

6]. Chen, H., J. De Baerdemaeker and V. Bellon. 1996. Finite element study of the melon for nondestructive sensing of firmness. *Trans. of the ASAE*. 39(3): 1057-1065.

7]. Davies, R. M., (2010). Some Physical Properties of Arigo Seeds. *Int. agro Phys*, 24:89-92

8]. Dutta S.K., Nema V.K., and Bhardwaj R K., 1988. Physical Properties of gram. *J. Agric. Eng. Res.*, 39, 259-268

9]. Gursory, S. and Guzel, E. 2010. Determination of Physical properties of some Agricultural Grains. *Research Journal of Applied Sciences, Engineering and Technology*. 2(5): 492 – 498, 2010.

10]. Jean R.K. and Ball S. 1997. Physical properties of Pearl millet. *J. Agric. Eng. Res*. 66, 85-91

11]. Joshi D. C., Das S.K. and Mukherjee, R.K. 1993. Physical properties of pumpkin seeds. J. *Agric. Engr. Res.* 54: 219–229.

12]. Karayel D., Barut Z.B., and Ozmerzi A., 2004. Mathematical modelling of vacuum pressure on a precision seeder. *Biosystems Eng*., 87, 437-444.

13]. Kasharineja M., A Mortazavi, A Safekordi and L.g. Tabil. 2005. Some Physical Properties of Pistachio (*Pistachia vera* L.) Nut and its kernel. *J. Food Eng*., 72:30-38.

14]. Kerje T. and Grum M., 2003. The origin of watermelon (*Cucumis melo)*: a review of the literature. www.vitacost .com.

15]. Koocheki, A., S.M.A. Razavi, E. Milani, T.M. Monghadam, S. Alamatiyan and S. Izadkhah. 2007. Physical properties of watermelon seed as a function of moisture content and variety. *Int. Agrophysics*, 21: 349-359.

16]. Koya, O.A and Adekoya, I.O., (1994). Some Physical and Aerodynamic properties of grain crops relevant to destoising. *Ife Journal of Technology*, 4(2): 35 – 40.

17]. Song, H. and Litchfield, J.B; (1991). Predatory methods of terminal velocity for grains. Trans. *ASAE,* 34(1): 225 – 231.

18]. Manuwa S.I and H. A. Muhammad 2010. Moisture Content and Compression Axial Effects on Mechanical properties of Shea kernel. *Journal of Food Technology* Volume 8: 3. Pp 94-99.

19]. Makanjuola, G.A. 1972. A study of some of the physical properties of melon seeds. *J. Agric. Eng. Res*., 17: 128-137.

20]. Mohsenin, N.N. 1970. Physical Properties of Plant and Animal Materials. Gordon and Breach Science Publishers, New York.

21]. Nwokolo E. and Sim S.J., 1987.Nutritional assessment of defatted oil meals of melon (*Colocynthis Citrullus*L.) and fluted pumpkin (*Telfaria occidentalis Hook*) by chick assay. *J. Sci. Food and Agri*., 38, 237-246.

22]. Oje, K., Alonge, A.F. and Adigun, Y. J., (2001). Some Engineering properties of shea Nut relevant to mechanical processing. *Ife Journal of Technology (IJT)*. 10(2): 17 – 26.

23]. Olajide J.O. and Ade-Omowaye B.I.O., 1999. Some physical properties of Locust bean seed. *J. Agric. Eng. Res*., 74, 213-215.

24]. Olaoye, J. O. 2000. Some Physical Properties of Castor Nut Relevant to the Design of Processing Equipment. *J. Agric. Eng. Res*. 77(1): 113-118.

25]. Paksoy M, Aydin C. 2004. Some physical properties of edible squash (*Cucurbita pepo* L.) seeds. *J. Food Engr*. 65: 225–231.

26]. Perkins-Veazie, P. and J.K. Collins. 2004. Flesh quality and lycopene stability of fresh cut watermelon. *Postharvest Biol. Technol*., 31: 159-166.

27]. Razavi, Seyed M. A. and Elnaz Milani. 2006. Some physical properties of the watermelon seeds. *African Journal of Agricultural Research*. Vol. 1 (3), pp. 065-069, October, 2006 Available online at http://www.academicjournals.org/AJAR ISSN 1991 - 637X © 2006 Academic Journals.

28]. Sahay, K.M., and K.K. Singh, 1994. Unit Operations of Agricultural Processing.1st ed. Vikas Publishing House Pvt. Ltd., New Delhi, India